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TABLE OF CONTENTS.

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RECENT FOREIGN STUDIES OF THUNDERSTORMS: IV. ITALY.*

R. De C. WARD.

THE systematic study of thunderstorms in Italy was begun in 1877, and the results of that year and of 1878 and 1879 were published by the Royal Observatory of Brera, at Milan (*Publicazione del reale Osservatorio di Brera in Milano*), the work in these years being done by Schiaparelli and Pini. In 1880 the Central Meteorological Office took up and greatly extended the investigation, and since then the reductions have been in charge of Dr. Ciro Ferrari, and the results published in the *Annali dell' Ufficio Centrale Meteorologico Italiano.*

The principal results obtained from the study of the thunderstorms of 1877–1881 have already been given in this Journal.† The present paper deals with the most important points brought out since then.

Dr. Ferrari has himself summarized his results for 1882 and 1883 in the *Meteorologische Zeitschrift*, Vol. V., 1888, 1–7, 62–81. This article is a translation of the most important parts of his *Studii sui Temporali del* 1882 *e* 1883, originally published in the *Annali*, Vol. VII., 1885, Pt. I., [77]–[215], and embodies all the noteworthy results obtained up to this time. It is, therefore, given considerable space here. Owing to the great number of reports received during these two years, only those days were selected for detailed study which brought many reports. The whole number of days thus studied was sixty-two, with 8,855

* The previous papers of this series will be found in this Journal, Vol. IX., 532–541; X., 111–126; 178–184.

† Vol. I., 1884–5, 379-380; Vol. II., 1885–6, 492–496.

separate reports. In addition to the thunderstorm records, use was made of many hundreds of rainfall records, and also of thunderstorm and rainfall reports from Austria and Switzerland, so that in all there were over 12,000 separate reports.

The main object of the investigation of these two years was to study the various meteorological elements at different altitudes above the earth's surface in the region of thunderstorm occurrence. The district selected for this study was the plain of the Po, which is well covered with stations; and, in addition to all the Italian observations, use could be made of certain of the Swiss and Austrian records. This attempt to systematically study the vertical distribution of the various elements in thunderstorms is the first one of the kind ever made, and Dr. Ferrari rightly appreciates the importance of such a study when he says that whoever follows up this path is almost certain to discover a great mass of facts. Charts were drawn representing the distribution of temperature and pressure, not only at sea level, but also at different heights above the earth's surface. In order to draw these charts it was necessary to infer that the temperature and pressure observed at the high level stations obtained also for points at corresponding altitudes in the free air. For pressure distribution this assumption is almost always true, but the temperature at high level stations is usually higher during the summer months than in the free air. These charts have isotherms and isobars drawn only when there are sufficient observations on which to base them, and on the isobaric charts the wind direction and state of sky are also noted. Relative humidity and vapor pressure are shown on one chart, which includes stations between sea level and five hundred meters, but as most of the stations are low, the mean height to which these charts refer is about one hundred to two hundred meters.

The progress of the thunderstorms is shown by isochronal lines, for every hour, representing the successive positions of the most violent part of the storm. In this connection mention is made of the great difficulty of clearly distinguishing between different storms which occur on the same day. Thunderstorms very often do not have a well-defined progression, but fade away very soon after their first development. On some days all the thunderstorms are of this kind. At other times many small local storms develop simultaneously at neighboring points, so

that there is great difficulty in separating them, this difficulty being caused by the vague times of occurrence and the wrong direction of movement given by the observers. "In order to rightly study a thunderstorm, which is the most complicated of all meteorological phenomena, and to clearly establish its relation to the distribution of the meteorological elements, the thunderstorm must not only be well defined itself, but all other meteorological phenomena (rainfall, etc.), which occur a certain time before the storm, during it, or after it, must also be clearly understood."

Isohyetal lines are drawn connecting places of equal rainfall, and curves are also drawn connecting places where there was equal display of electrical energy. For the purpose of determining this point a scale was adopted with grades according to the severity of the thunder and lightning, the grades being designated by numbers. The isobaric charts for different levels vary somewhat in accuracy, the higher the level for which they are drawn the more unreliable the lines become. The error is, however, for isobars between 500 and 600 meters, probably only ± 1 mm., and for higher levels ± 2 mm. The isotherms for the lower levels are within $\pm 1°$–$2°$, those for intermediate levels within $\pm 2°$–$3°$, and those for the high levels within $\pm 3°$–$4°$.

A careful tabulation of the thunderstorms of 1880–1883 shows that the majority of storms come from northwest and west; and that those from the western quadrant have the greatest velocity, while those from the eastern have the least. The mean hourly velocity (in kilometers) for the four years, by months, is shown in the following table:—

April.	May.	June.	July.	August.	September.
36.0	32.0	35.5	42.4	35.9	33.9

From this it is seen that thunderstorms have a greater velocity in summer than in spring or fall. The velocity of thunderstorm movement has a close connection with the wind and with the electrical phenomena, for the greater the velocity of the storm, the stronger is the wind that accompanies the latter, and the more violent are the thunder and lightning. The occurrence of destructive hail-storms seems also to be limited to the fastest moving thunderstorms.

The days which bring many reports and distinct thunderstorms are of two types. The first produces numbers of small

storms; the second brings one extended thunderstorm, generally accompanied by others of less extent. In the first case small thunderstorms develop at different places and follow or lap over each other. These occur almost exclusively between 1 and 4 P. M. In the second case a single large storm crosses an extended district in an indefinite interval, while the smaller storms, which also develop on these days, keep their usual characteristics, though with somewhat less distinctness, and prevail in the afternoon hours. On the days of the second class more than one extended thunderstorm may occur, but one can always be distinguished as the main thunderstorm. This main storm is frequently the last one noted during the day, closing the period of thunderstorm activity, or else it may be followed by smaller storms.

The thunderstorm may be regarded as a band which is straight, curved, frequently irregular, and which, at successive intervals of time, occupies positions parallel to itself. The storm is not to be regarded as a distinct phenomenon which, as a solid whole, moves from place to place, but rather as a process which develops progressively, depending partly on the previously existing local conditions. It partakes, therefore, of the nature of a wave. There may be two distinct kinds of development: one in which there was one centre at the start and the storm moves on regularly and continuously; the other in which new centres may be developed in the advancing wave. This latter phenomenon has frequently been noted in thunderstorms, and corresponds with the formation of secondary cyclones, which may, owing to the filling up of the primary depression, themselves become primaries; and with a similar tendency in anticyclones. Other features of interest regarding the movement of thunderstorms are the breaks which are often noted in the storm-front, some districts being left entirely without rain or electrical manifestations, while other places, on either side, feel the full effects of the storm; the greater velocity of movement at the central axis of the storm, shown by the greater distance between the isochronal lines at the centre, and the rapid succession, in some cases, of what are usually regarded as separate storms, but are really different waves of the same storm.

With regard to the mode of origin of the thunderstorms of Italy there is much uncertainty, largely because they very often

come into Italy fully developed from some outside district. In cases in which the thunderstorms begin within the borders of Italy they are first noted as a point, and then spread out after the manner of the sector of a circle.

The chief causes of thunderstorm development are high temperatures, high vapor pressure, and calm atmosphere. The former warms the surface of the earth and causes an upbending of the isotherms and the formation of an area of low pressure. If the pressure was even before, then this depression continues by itself, but if this was not the case, then this newly formed low area joins itself as a secondary to a previously existing depression. In either case the cause of development is local.

The general relations of the thunderstorms of 1882–83 to the barometric pressure at sea level are the same as those determined in the case of the storms of 1880–81, and the results then obtained for sea level as regards isobars and isotherms are now found to be true for all levels for which charts have been drawn, based on the records of 1882–83. These relations are as follows: Every thunderstorm is connected with a barometric, a hygrometric, and a thermometric depression. It is always in the rear of the first two, and in the front of the last one. All these depressions, and especially the last two, are connected with corresponding maxima, which are situated behind the barometric and hygrometric, and in front of the thermometric, depressions. In other words, the storm-band is between an area of high temperature in front of it and low temperature in the rear. The humidity is low in front of the storm and high within it. The storm comes on the after side of a faint area of low pressure.* The barometric and thermometric gradients are found to increase from sea level to a height of 200 to 600 meters, and then to decrease again. A tabulation of the changes in temperature at stations at different levels during a number of well-marked thunderstorms shows that the greatest fall in temperature takes place between sea level and 600 meters. A figure representing the isotherms at different altitudes in the thunderstorm region and behind it shows that before the storm they are convex; after it concave, and that the double curve

* For diagram see Met. Zeitschr., Vol. II., 1885, 372; also this JOURNAL, Vol. II., 1885-86, 495.

gradually disappears with altitude, so that at some considerable height a neutral plane will be reached where the isotherm will be parallel to sea level. In this figure the isotherms in the district before the storm are drawn on the basis of the usual decrease of 1.6° F. for every three hundred feet of height.

The typical curves of the self-registering instruments at different heights during thunderstorms were studied by reference to the records made at Rome, Bern, and the Säntis, whose heights above sea level are respectively 50, 573 and 2,500 meters. The period embraced in this study, for all the stations together, included eight years, with ninety-five cases, for day thunderstorms, and eighteen years, with seventy cases, for night thunderstorms. The typical curve for day thunderstorms in the lower atmosphere may be described as follows: Before the storm, the pressure and relative humidity fall and the temperature rises in such a way that the first two elements attain a minimum and the second a maximum at the moment of the storm's beginning. Thereupon the pressure and relative humidity rise rapidly, and the temperature falls, the first two elements often reaching a maximum and the last a minimum at the end of the storm. The temperature curve is exactly the reverse of the pressure and humidity curves. The wind, which before the storm has a slight or a zero velocity, increases rapidly as the storm begins, attains a maximum at or shortly before the ending of the storm, and then quickly decreases again. This typical course of the various elements does not hold exactly in every case, but the departures are usually slight. The curves at different altitudes above the surface are found to be very much the same, with the exception that the barometric changes are lacking or are much less marked at the level of the Säntis. Night storms show less pronounced fluctuations than day storms.

The usual form of the depression in connection with which thunderstorms occur is that of an ellipse, whose major axis is perpendicular to the axis of the thunderstorm. The little anticyclone which sometimes follows the depression is probably also elliptical. The temperature depression following the thunderstorm is elliptical as well, and its major axis is also perpendicular to the axis of the thunderstorm. The path of the barometric depression coincides with that of the thermometric depression, and both probably correspond with the axis of the thunderstorm,

so that the latter may be regarded as the place where all the accompanying conditions attain their maximum of intensity. It has been seen that the typical thermometric curve is noted as far up as 2,500 meters above sea level, while the typical barometer curve is not usually noted at that height. From this it follows that the thermometric depression extends to a greater altitude than the barometric, although the upper limit of both is variable.

The occurrence of thunderstorms in barometric depressions leads to a statement as to the resemblances and the differences between thunderstorm depressions and ordinary depressions. They resemble one another in their elliptical form, the spiral circulation of the winds around them, and frequently in their movement. The differences are that thunderstorm depressions always move, while ordinary depressions sometimes stand still. The latter also, except in the case of rapidly-moving severe cyclonic storms, do not show the typical thunderstorm temperature curve, which is the reverse of the barometer curve. Thunderstorms, according to Ferrari, are, in the main, phenomena of a local nature, which are superimposed on the general phenomena of the atmosphere ; they are like a short local and acute sickness of the atmospheric organism.

The wind which comes in connection with a thunderstorm has, as a rule, the same direction as that of the storm's movement, but this is true only when the thunderstorm is fully developed. In the majority of cases the wind blows around the barometric depression of the thunderstorm according to Buys-Ballot's law. The squall-wind attains its maximum velocity where the gradients are the steepest, which is in the lower one hundred metres of the atmosphere, or at sea level. The upper limit of the wind varies in height ; in large and violent storms it may reach 2,500 metres, but oftener it is very much lower. In some cases where the wind is very violent at low levels it is hardly influenced at all at higher levels. As a rule small local storms are accompanied by a moderate squall-wind, and the more extended the thunderstorm, the more violent is the wind which it brings.

The synoptical study of the distribution of relative humidity in the thunderstorms of 1882–83, as in those of 1880–81, shows clearly that a minimum of relative humidity precedes a thunderstorm and a maximum follows it, and it is probable that this

holds true not only for sea level, but also for higher levels, the lines of relative humidity being the reverse of those of temperature.

A tabulation of the daily frequency of the thunderstorms of 1880–83, according to the number of hours during which the storms prevailed, brings out some interesting facts. It appears that the maximum in the early afternoon hours is due to the small local thunderstorms, which last from one to three hours only. The greater the extent of the thunderstorms, the less marked the afternoon maximum becomes, until, in storms lasting over nine hours, there is a very even distribution throughout all the hours of the day, with a slight maximum in the later afternoon hours. Thunderstorms lasting over nine hours are most frequent in the spring and fall, and least frequent in July.

The form of the rain area of a thunderstorm, as shown by the isohyetal lines, is that of an ellipse, whose major axis is about parallel to that of the thunderstorm axis. Within this area there are different centres around which the isohyetal lines group themselves. The height to which the Italian thunderstorms extend may be taken as often over 4,000 meters, for these storms frequently come from France fully developed and cross the intervening mountains without difficulty. While rain falls at low levels, snow falls at higher altitudes. Measurements of the snow line have shown it to be from 1,000 to 1,300 meters for single cases in June and July. In various instances rain has fallen from a thunderstorm, and has been followed by snow, this going to indicate that at high levels high temperature precedes low temperature. Hail occurs in narrow bands having the same direction as that of the storm's movement, and in connection with the most rapidly moving storms.

Lightning has been noted as being seen from a thunderstorm three hundred kilometers distant. It is a habit of thunderstorms in Italy to come in succession. Thus if one storm crosses a certain region others are apt to follow it, over the same district and in the same direction. The interval between the first and the following thunderstorms is generally three hours, or some multiple of three hours, preferably twenty-four.

Ferrari has written "*Andamento tipico dei registratori durante un temporale*," published in the *Annali* for 1885, Part I., 65–76, and translated in *Das Wetter*, Vol. IV., 1887, 193–208. The

principal points in this article are embodied in the longer paper already reviewed.

The data collected during the six years, 1880–85, were made the basis of an investigation by Ferrari into the thunderstorm coefficients of the various districts of Italy, published under the title of "*Determinazione dei Coefficienti temporaleschi della Regione*," in the *Annali*, for 1887, Vol. IX., 59–97. Ferrari considers a "thunderstorm unit" a thunderstorm of average intensity and of average duration over a district of ten square myriameters (a surface of about twenty miles on a side). The average intensity is reckoned according to the average electrical disturbance, hail, rain, and wind velocity of the thunderstorm. The average duration is taken as one and a half to two hours at each station. The average thunderstorm is reckoned as I, and with this as a standard all the thunderstorms of the different districts into which Italy is divided in this investigation are compared, the coefficients for the different districts varying above or below I according as the thunderstorms are above or below the average.

An article on "*Vitesse et Direction des Orages en Italie*," in *Ciel et Terre*, III., 1887–88, 67–73, based on the records of the two later years, confirms the results derived from a study of the data obtained in 1882–83.

Ferrari's work is the most systematic and complete of any investigation of thunderstorms that has yet been made, and his memoir above summarized presents the main results of his labors in a concise and exact form. His conclusions are of great importance, based as they are on very careful work, and his memoirs are most elaborate in their detail of statistical discussion and graphic representation. The charts are clear and record all the important facts of occurrence of rain, hail, thunder, lightning, wind direction and force, etc. Ferrari began, in 1880, with a study of the movement of thunderstorms and their relation to temperature and pressure. In 1881 he went further into the distribution of rainfall, electrical phenomena, etc. Finally, in 1882–83, he still further extended his plan, his aim being to investigate the distribution of the various elements in thunderstorms at different heights above the earth's surface. The object throughout has been to gain a knowledge of the mechanism of thunderstorms, a point which, in the general

endeavor to present a mass of statistics, has frequently been lost sight of in other countries.

The thunderstorm observations made in 1884–88 have been regularly published in the *Annali* for 1887–90 under the direction of Dr. Ettore Ferrari, but there has been no further discussion of them.

Harvard College, Jan. 1, 1894.

CERTAIN CLIMATIC FEATURES OF MARYLAND.*

WILLIAM B. CLARK, DIRECTOR, MARYLAND STATE WEATHER SERVICE.

THERE are few regions in this country where so greatly diversified physiographic features are presented within so limited an area as in that of the State of Maryland. Bounded by the ocean upon its eastern border the State is very nearly bisected by the Chesapeake Bay, the largest arm of the Atlantic within the United States, while the western district crosses the main chain of the Appalachians to the Ohio drainage.

In a region so diverse the greatest variation in the climate may be anticipated. Some recent work by the Maryland State Weather Service in tabulating all the records of temperature and precipitation which were attainable show a very intimate connection between the leading features of the climate and topography of the State.

Maryland is only a portion of a larger topographic region which includes the entire Middle Atlantic slope. Like the larger area of which it is a part it may be divided into three leading topographic belts, known respectively as the Coastal Plain, the Piedmont Plateau, and the Appalachian Region.

The Coastal Plain forms the eastern portion of the State and comprises the area between the Atlantic Ocean and a line passing from northeast to southwest from Wilmington to Washington through Baltimore. It is nearly one hundred miles broad in its widest part, and is characterized by broad level-topped stretches of country, which extend with gradually increasing elevations from the coastal border, where the land is but slightly raised

* Read before the Geological Society of America, at Boston, December, 1893.

above sea level, to its western edge where heights of three hundred feet and more are found. The Coastal Plain is divided into a lower eastern and a higher western division, separated by the Chesapeake Bay.

The Piedmont Plateau borders the Coastal Plain upon the west. It is about forty miles in width in the southern portion of the State, but gradually broadens toward the north until it reaches sixty-five miles. The country is broken by low undulating hills which culminate in the central portion of the region as Parr's Ridge which reaches eight hundred and fifty feet in elevation. The broad Frederick Valley stretches along its western slope to the flanks of the Appalachians.

The Appalachian Region comprises the western portion of the State. It consists of a series of parallel mountain ranges with deep valleys, which are cut nearly at right angles by the Potomac River. Many of the ranges exceed two thousand feet, while some reach three thousand feet and more in the western portion of the district. The Appalachian Region is divided into three distinct districts, — an eastern (Blue Ridge and Great Valley), a central (Appalachian Mountains proper), and a western (Alleghany Mountains), which are separated from one another upon clearly defined differences in their geological structure. In the eastern portion of the region the tributaries of the Potomac have carved out deep valleys in the softer beds, while in the western district the streams have only been partially adjusted to the geological structure of the country over which they flow. The separation of the drainage in the western district has particular interest since it marks the watershed between the streams which flow into the Potomac, and thus reach the sea by the eastern slope of the Appalachian Mountains, and those which flow to the Gulf by way of the Ohio and Mississippi rivers.

With this brief outline of the topographic features of the State, attention may now be directed to some of the more striking characteristics of the climate.

Comparing in a broad way the high mountainous district of the western portion of the State with the lower areas in the central and eastern part, a marked difference is seen in both temperature and precipitation. The average annual temperature of the extreme western portion is 50°, while along the east-

ern border it rises to 58°, the annual mean for the entire State being 53.8°.

More pronounced variations are seen, however, when the comparison is made by seasons. Thus, in the spring, the range in temperature between the western and eastern portions of the State is from 44° to 56°, a difference of 12°; in summer, from 69° to 77°, a difference of 8°; in autumn, from 50° to 60°, a difference of 10°; in winter, from 27° to 40°, a difference of 13°.

The precipitation likewise shows a very perceptible difference in the western as compared with the other portions of the State. The average yearly precipitation of western Maryland is, approximately, 38.5 inches, while in the other portions of the State the average is very nearly 44 inches.

It is, however, when the details of the topography are studied that the most striking features appear. Thus the annual isotherm of 50°, which passes over the Alleghanies and Appalachian Mountains proper, after passing to the northward into Pennsylvania, bends down again along the highland of the Piedmont Plateau, while, on the other hand, the broad Frederick Valley is invaded throughout most of its length by the isotherm of 53°. The highland of the Piedmont Plateau shows, throughout, a considerably lower mean temperature than the low areas on either side of it. The greater portion of the eastern and southern districts of the State is included between the isothermals of 55° and 58°, the influence of the ocean and bay being shown throughout the Coastal Plain.

The effect of the leading topographic features of the State in modifying the temperature is shown even more prominently when the seasonal isotherms are examined, the highlands being universally cooler than the lowlands.

Equally pronounced variations are shown in precipitation. Thus the broad Frederick Valley, lying as it does on the eastern flank of the Blue Ridge, receives an abundant rainfall from the moist southeasterly winds. There is also a pronounced increase in the volume of precipitation in passing inland from the Atlantic border. There are certain very striking local variations in precipitation, however, that it is impossible to assign to topographic differences, and at present no suitable explanation can be given for them.

The work thus far accomplished by the Maryland State

Weather Service is considered merely as preliminary to a fuller study of the climatic features of the State, but even with the data at hand, the close association of the climate with the topography is clearly indicated.

TEN MILES ABOVE THE EARTH.

PROF. H. A. HAZEN.

TO most persons this title will have very little significance, and yet we may hope for most important discoveries from this region in the future. What is the velocity and direction of its currents? its temperature? its electric condition? and what changes take place as our storms, cold waves, hot waves, etc., sweep along, perhaps stretching their tops even above this most lofty height? I would not be misunderstood, however; with all the interest which such exploration arouses, there comes the further thought that there should be, first, a most thorough study of all these conditions in the region nearer the earth. Such a study will enable us to better explain any anomalies or mysteries brought back from the still higher regions. The uncertainties of records from these most lofty heights may be greatly reduced, but they cannot be wholly overcome; more than this, there can be little doubt that most of the atmospheric conditions affecting the earth's surface take their origin at heights far within the reach of direct observation, and it is easy to see that these should have the first attention.

The only partly successful effort to bring back news from such an enormous height was on March 21 of the present year, by M. G. Hermite, in Paris. The balloon used was named L'Aerophile, and was made of gold-beater's-skin. This substance bids fair to revolutionize the whole art of ballooning. To those of us who have had experience with 100,000 and even 160,000 cubic feet balloons which it was impossible to keep afloat more than four or five hours, it will come as almost a revelation, that a balloon made of this material (*baudruche*, the French call it), of only 25,000 cubic feet, will keep one man afloat for thirty days or more! It is estimated that such a balloon will lose only one per cent of pure hydrogen in twenty-four hours, and some have lost only one half of one per cent! The weight of these

balloons is about one half of those ordinarily built, which rarely stay afloat more than twenty-four hours at best, unless made three or four times as heavy. L'Aerophile was about twenty feet in diameter, and held a little less than 4,000 cubic feet. The weight, including net, was three ounces to the square yard. The only other balloon of which I have been able to get correct figures was the "Carlotta," of about 9,000 cubic feet capacity, and having a weight of about eight ounces to the square yard.

As near as I can learn, even the latter is an extraordinarily light balloon, as they run up to twelve to twenty ounces to the square yard. It is most gratifying in reading accounts of this experiment in Paris to find the details so carefully given. In the four ascensions with different balloons that I have made, it has been found impossible to get accurate figures giving the weight of the cloth, net, basket, valve, etc. In fact, there is so much rivalry among balloon makers that they are very unwilling to let out these details.

The instruments sent up were self-registers for pressure and temperature besides other simple contrivances. One of the most important parts of the outfit, the sun screen, was left off in the final arrangements owing to the need of great haste to avoid accident from the high wind; this proved in the end to be a great calamity. The thermograph employed had a bent box or Bourdon tube filled with alcohol for indicating changes in temperature. Some experiments in this country at low temperatures have shown this instrument liable to freaks, and this may account for some of the anomalous results obtained in this experiment. There is one point insisted upon by the French which seems to be far from correct. It is claimed that the balloon should be filled full of gas before starting; if it is not, a series of waves or surges will be set up in the interior and these will serve to tear the balloon. Now it is well known that if a balloon has a good buoyancy at the earth it will rise with great rapidity to the highest point to which it can possibly attain and the velocity will be nearly uniform. In such a case we need fill a balloon, which is to reach ten miles, only about one fifth full. Now, suppose we fill the balloon, or put in five times as much gas, the buoyancy will be five times as great, it will spring from the earth almost as if shot out of a cannon, the expanding gas will strain the envelope and net to the utmost, and it

would seem, from any possible point of view, that the danger of rupture would be vastly greater than where the balloon starts with less buoyancy. This is not all: in such a rapid rise the instruments cannot possibly keep up with the change in pressure or temperature and, in consequence, the result will be greatly in error.

It was hoped to use hydrogen with L'Aerophile, but at the last the apparatus for generating the gas was found out of order, and coal gas having a lifting power of about forty-five pounds to the thousand cubic feet was used. The start was at 12.25 with a buoyancy or ascensional force of one hundred and forty-three pounds. The table gives the most interesting facts:—

RÉSUMÉ OF OBSERVATIONS OF THE ASCENSION OF L'AEROPHILE, MARCH 21, 1893.

TIME.	Barograph pressure, inches.	Height not corrected for temperature. Feet.	Temperature, degrees Fahr.	Vertical velocity feet per second.	Decrease of temperature with height.	REMARKS.
12.25	29.7	213	63		1° in.	Start. Vaugirard.
.30	21.6	8,530	39	28.2	350 ft.	
.35	15.8	16,730	14	27.2	337	
.40	12.0	23,950	—11	24.6	321	
.45	8.5	33,000	—40	30.2	318	
.50	6.3	40,910	—60	26.4		Intense solar radiation causes too high temperature.
.55	5.2	45,930	—55	16.7		
.57			—52			Interruption of traces from freezing of ink.
14.30	4.06	52,500	[—104]		[313]	Beginning of barograph trace.
15.15	4.1	52,280				
16.5		50,850	—6			Beginning of thermograph trace.
17.11	4.7	48,560	—10			
.21			—20			Barograph trace stopped.
.31			—21			
.41			—28			
.51	7.1		—36			
.55		37,730	—41			Approximate height.
18.1			—44			
.11	9.1	31,170	—53		299	Sunset at Paris but not at balloon.
.21			—40			
.31			—15			
.41			7			
.43	18.8	12,140	9			Barograph trace begins.
.45	19.5	11,160	14	8.2	301	
.50	21.3	8,860	19	7.5	275	
.55	23.1	6,730	27	7.1	278	
19.00	24.8	4,920	31	6.0	242	
.5	26.7	3,020	38	6.2	224	
.11	29.53	328	50	7.5		Landing at Chanveres, 77.7 miles southeast of Paris.

The balloon landed at Chanveres near Joigny, having been afloat six and three-quarters hours. It is noted by M. Hermite that probably during the most rapid rise and fall there was sufficient ventilation to give fairly accurate temperatures, but at the highest part of the trip, the air was so stagnant and the solar radiation so great that the temperature was entirely erroneous.

This view must be accepted with caution, however, for at 12.55 with the velocity of 16.7 feet per second the temperature began to rise. This remarkable rise of 5° at a velocity of 16.5 feet, is attributed by M. Hermite to the influence of solar radiation, but it is doubtful if that is the whole explanation.

We see that, according to the law of the diminution in temperature in the above table, the lowest temperature at the highest point reached was not far from —104° Fahr., or a diminution of 1° per 313 feet, which is the usual law. A rather curious computation of this lowest temperature is made by M. Hermite on the basis of the probable difference in temperature between the gas in the balloon and the outside air. He assumes the temperature of the gas as —4°, or nearly the same as that indicated by the apparatus, and computes the equilibrium point of the balloon, if its gas and the outside air were at the same temperature, as 43,290 feet. At this point, however, the balloon, instead of coming to rest, was really ascending at the rate of about 20 feet per second, and it rose over 9,000 feet farther. It is suggested that this could only have taken place under intense solar radiation, and to give this increased buoyancy the gas must have been 252° hotter than the air. This gives at once the temperature of the air as —256°; and it is calculated that the absolute zero of temperature, —459° Fahr., will be reached at 85,303 feet, and that this height may perhaps be reached by a hydrogen balloon. The temperature of unlimited space was computed by Pouillet as —224° and by Herschel as —239°. It would appear that the —104° given by the law of diminution should be taken and not the other, as there are altogether too many uncertainties connected with that computation. At the altitude of 16,000 feet in a balloon, I very much doubt if a free thermometer in the sun will read more than four or five degrees higher than in the shade, and at the height of 50,000 feet there may be a difference of 25° or 30°, but hardly more than that. In the case of the balloon only a small part of a hemisphere

would be exposed to the normal sun's radiation, while a whole hemisphere would radiate its heat to space and the whole spherical surface would conduct its heat to the surrounding atmosphere, assumed in this case to be 252° lower in temperature.

It should be noted also that the temperature correction for —104°, according to the formula of Laplace, would give a *lower* elevation by 7,100 feet than that computed by M. Hermite. At —256°, the temperature correction would be —15,000 feet, which would give the final elevation as 37,500 feet only.

This experiment was wonderfully successful and shows perfectly how much more we are to gain from its experiences.

On Dec. 18, in the evening, a similar research was attempted at St. Louis, Mo. In this case the same kind of gas was used but it was not so dry and would not lift more than forty pounds to one thousand cubic feet. The balloon was sixty-five feet in diameter and contained over one hundred thousand cubic feet! The weight of cloth, net, etc., is not at hand. A Richard barograph and thermograph were fitted to run at much greater speed than ordinarily, and at very much lower pressures and temperatures. A camera with a shutter working automatically was to take photographs of the earth the next morning. An arrangement was attached to throw off ballast at intervals. It is needless to add that no man accompanied the balloon. The path seems to have been toward the Great Lakes, as the balloon was seen at Springfield, Ill., and, moreover, there was a very violent storm in the lake region which would probably cause a motion toward itself. Observations on Mount Washington have shown that under the conditions here noted the upper current must be anywhere from sixty to two hundred miles per hour. If the balloon should stay afloat sixty hours, and the velocity continue at one hundred miles per hour, it would carry the balloon one fourth of the way around the earth. Of course, there are no such long distance steady currents as these, but it would seem that in this case steps had been pretty effectually taken to permanently lose the balloon. Of course, for the purpose of this kind of exploration, it is very essential to send up the balloon in broad daylight so that it can be followed, and to make its excursion not more than four or five hours long. It is very much to be hoped that a first failure will not lead to an abandonment of the research.

DEC. 22, 1893.

MEASUREMENT OF THE SEASONS.

H. GAWTHROP.

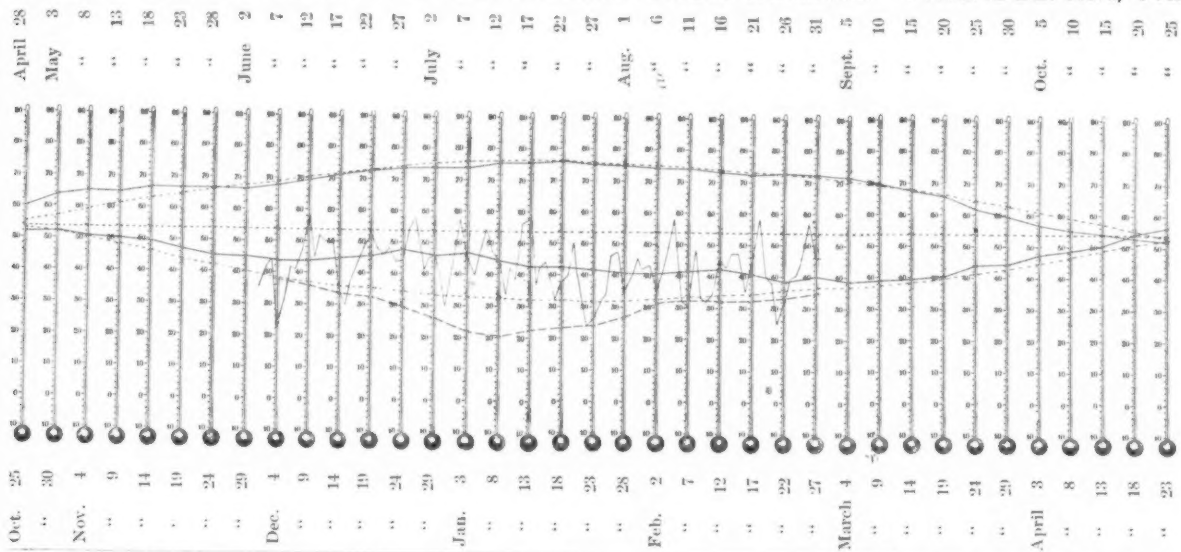
THE subject of warm or cold winters and summers, early or late springs and autumns, and dry or wet seasons, is perennial. Of more interest even than the discussion of the weather of the day is that of the past, present, or future character of the seasons. The look ahead can hardly yet be counted by days, but bearings can be taken of the past and present conditions, with some hints as to the future.

It is customary now for the daily newspapers to publish the normal and mean temperatures of the air, as part of the record of the preceding day, furnished by the Weather Bureau. The difference between the mean and the normal is stated as the excess or deficiency, and a summary is also given of the departures since the first of the month and first of the year. This latter, however, is not satisfactory, for nature does not group weather conditions according to the calendar, but in irregular periods of varying character. It is proposed in this paper to present a method by which, using the daily means as the unit, the progress of a season may be determined and graphically illustrated.

If we should take the average of the daily mean temperature for the month of September, and enter as of the 16th, the morning of that day being midway of the month, and then should drop the mean of the first day of September and take up that of the first day of October, averaging again for thirty days, entering the result on the seventeenth day of September, and continuing thus, dropping the first day of the period and taking up the next succeeding day, entering the average consecutively, we would have a progressive mean of the temperature for thirty-day periods. The same method can be followed with the normals and departures, there being an advantage in the use of the latter, instead of the means, to determine the course of temperature, because of the light figures involved.

By the method proposed, the writer of this has prepared tables showing the course of temperature at Philadelphia, Pa., for several years. Selection has been made for the chart of a period covering one year, and including the phenomenally warm winter

NORMAL TEMPERATURES AND DEPARTURES FROM NORMAL. PHILADELPHIA, PA.



In the Chart are shown: (1) The yearly mean by the straight dotted line; (2) the normals by the curved dotted line; (3) the daily means for the winter months of 1889-90 by the zigzag line; (4) the course of temperature, as averaged for thirty day periods for the year, from April 28, 1889, to April 23, 1890, by the solid line, and (5) the same for winter months of 1892-3 by the broken line.

of 1889–90. To save space the general course of temperature in shown every five days only, but the means are traced for each day of the winter named, being limited to that period to avoid confusion. The zig-zag lines, so introduced, are a good illustration of the perpetual alternation of warm and cold in our climate and the wide range of the daily mean temperatures even in a mild winter.

By experiment it is found that a thirty-day average spans these undulations or waves better than would a shorter period, and that it is not so long as to modify the result to any great extent by reason of the curves. The course of temperature can be traced by the solid line from April of the one year, at left of chart, to October, at the right, and then returning to the left, from October to April of the next year, at the right. It will be seen how closely the course follows the trend of the daily means where they are shown. That comparison may be made, the course for the cold winter of 1892–3 is also given in the broken line.

Incidentally, attention is called to the use made of thermometer scales in the chart. As in the well-known weather map much explanation is saved, the scale, like the outline map, being a familiar object. The latter, for most part, is used to illustrate conditions in space, while the former, so far as temperature is concerned, can be used to show the changing conditions for time.

The course of temperature at any one of our central or eastern stations represents closely, in the wide departures, the general conditions for the territory from the Rocky Mountain slope to the Atlantic coast. In precipitation, however, the result at one station is much more of a local character, and the average of several adjacent stations is necessary to give a measure of any general drought or excessive rainfall.

Nevertheless, the method suggested, to find the course of temperature, with some modifications, may be used to determine the general course of precipitation. The practice is to tabulate weather records in monthly, ten-day, or five-day periods, one following the other, while, in the plan proposed, the periods overlap in a manner to secure a better measure of general movements.

The chart illustrates three phases of temperature: (1) the variation of the daily means; (2) the seasonal changes; and

(3) the departures from the normal. The cause or causes of this last phase, the varying character of our seasons, is a problem yet to be solved.

THE CLIMATE OF LOUISIANA.*

R. E. KERKHAM.

Compiled from State Weather Service Records of Past Six Years.

THE Louisiana Weather Service has been in existence for the past six years, and during that period has collected meteorological observations from all the parishes. The service is conducted under the auspices of the Weather Bureau of the United States Department of Agriculture; the observers making the observations are esteemed in their respective communities for their worth and integrity, and have been properly educated in the manner of making observations; the instruments used are of standard pattern, and it is therefore evident that the records collected and compiled are trustworthy and official. An occasional record was found where the location or exposure of the instruments did not give readings that were comparable with surrounding stations, and in such cases steps were immediately taken to remedy the existing evil, but the erroneous records were not used in the compilation of the tables herewith.

The division of the State into the northern and southern sections was found necessary; in fact, a third section (the coast district) might have been added, since the parishes bordering on the Gulf have a more equable temperature, a greater immunity from frosts, and have other peculiarities not found in the interior or north portions.

The greatest extremes of temperature, with the least annual average rainfall and earliest frosts, are naturally found in the northern section, being more remote from the tempering Gulf winds; on the other hand, the coast district shows the greatest average annual rainfall, the lowest summer and highest winter maximum temperatures, and highest winter minimum temperatures. The difference between the several sections amounts to as much as twenty degrees in the annual range of tempera-

* Reprinted from the Louisiana Weather Journal and Agriculturist, Nov. 10, 1893.

ture; for while the Gulf section has a highest maximum on record of 97°, the interior parishes have 103°; and while the minimum of the coast district in the past six years has been 26°, for the interior and northern sections it has been 13° and 11°, respectively.

The coast district has an average annual rainfall of 56.50 inches; grouped with the remainder of the southern section the average is 54.19°, while the northern section has 48.20°, or six inches less.

The climate of North Louisiana is more favorable to cotton, its principal staple; while in South Louisiana sugar cane ranks first. The former is a sun plant and does not require the generous showers cane demands for its sustenance and proper growth. While frosts of a damaging nature seldom occur early enough in the northern section to injure cotton, yet a six-year average places the date of first killing frost in the southern section about two weeks later, and along the coast it is a month or more later than that for the interior of the southern section (the average date of first killing frost in the vicinity of New Orleans occurring Dec. 19). This frost date is that for the open country, and from actual observation.

A lengthy discussion of the tabular matter appears to be unnecessary.* The figures speak for themselves, and emphasize the fact that Louisiana's climate is unrivalled by any State in the Union. It is a regrettable fact that State weather service normal data have not been compiled for the majority of the States, so as to permit of comparisons covering the same period of time. As an illustration, however, of the widely different climatic characteristics of two agricultural States we will consider the annual summaries of Iowa and Louisiana for 1891. Iowa's mean temperature for the year was about 47°; Louisiana's, 67°. Iowa's extremes of temperatures ranged between a maximum of 106° and a minimum of 31° below zero, or an annual range of 137°; while Louisiana experienced an extreme maximum of 103°, an extreme minimum of 20° above zero in the interior parishes, or an annual range of 83°. Along the coast district, however, the extremes were only between a maximum of 94° and a minimum of 32°, or an annual range of 62° — considerably less than half the

* The tables are here omitted.

Iowa range. Iowa's rainfall was about thirty-seven inches; Louisiana's was fifty-one inches. Iowa had a first white frost on Aug. 28; North Louisiana had its first white frost on Oct. 20, and the interior of South Louisiana had it on Nov. 18, while the coast district had it Nov. 30.

Iowa's climate will stand for the agricultural Northwest and West; it is more equable than the Dakotas and Minnesota, but possibly a trifle more extreme than Kansas, Missouri, and other States farther south.

In a question of the humidity for Louisiana compared to that of the upper Mississippi and Missouri valleys and the extreme Northwest, we find from a record covering from 1870 to 1885 that the mean annual relative humidity of the upper Mississippi valley is 69%; the mean for the Missouri valley is 69%, and for the extreme Northwest is 74%, while Louisiana is 71%, being but two per cent above the averages of the two first-named sections, and three per cent below the latter. The highest mean monthly in Louisiana is but 74% against a highest mean monthly of 91% in either of the three other sections under consideration.

Special attention is invited to the fact that two hundred of the three hundred and sixty-five days in the year are clear in Louisiana, or a percentage of sunshine between fifty-five and sixty per cent; also, that there are an average of but eighty-five days on which appreciable rain falls, considering the State at large, and that the number of clear, partly cloudy, cloudy and rainy days is very nearly the same in both northern and southern sections.

CURRENT NOTES.

The New Harvard College Meteorological Station on the Misti (19.200 *feet*) *in Peru.* — The following is a translation of a letter written by Prof. S. I. Bailey, of the Harvard College Observatory at Arequipa, published in "La Bolsa," an Arequipa newspaper, of November 10, 1893: —

THE NEW METEOROLOGICAL STATION ON THE MISTI.

THE EDITOR OF "LA BOLSA":

Dear Sir, — Knowing the interest which Peruvians take in scientific progress, and especially in all the observations made in connection with the famous volcano of Arequipa, I take pleasure in giving them the following facts concerning the meteorological station recently established on the summit of the Misti.

In order to thoroughly equip and maintain this station a mule path was a great desideratum, for, although a person might reach the top on foot once or twice, it would, in the absence of such a path, be very difficult to secure an intelligent person to visit the station regularly and to make the necessary observations. The experience of those who have ascended to great heights has usually been that the fatigue due to their extraordinary efforts has incapacitated them for making exact observations. We have never heard it said that mules have ever ascended to so great an altitude as the summit of the Misti, but our previous experience with them at altitudes of 17,000 ft. convinced me that, with proper care, they can ascend to the height of 19,000 or even 20,000 ft.

Of all the mountains around Arequipa, the Misti, by reason of its splendid isolation and symmetry, is the best adapted for a prominent meteorological station. An expedition was made in August which made a complete circumference of the volcano for the purpose of studying the possibility of constructing a mule path to the summit. Minute investigation was made with good field glasses of all sides, and we took some photographs. Seen from any direction the Misti shows a surprising symmetry, always presenting a more or less truncated but almost perfect cone. The examination convinced me that the mountain was accessible on the northeast. In August a stone hut was built on the northeast side of the volcano, as a station, and after that I passed several days there, superintending the work of constructing the above mentioned path to the summit. By not avoiding the great slopes of volcanic sand and by keeping away from the ledges I did not find it an impossible undertaking, as many had feared.

On Sept. 27 I succeeded in reaching the summit, with an assistant, several Indians, and two mules. By proceeding on foot and by mule alter-

nately we arrived in good condition to make scientific observations, and the mules were not at all injuriously affected. Nevertheless, the altitude produced a great effect on the latter, and near the summit they refused to move more than twenty feet without a good rest. Without such extreme care they would probably have succumbed to mountain sickness.

On Oct. 12 I again visited the summit with two members of the Observatory, twelve Indians, and thirteen mules, taking up a portable hut with double wooden walls. We also took up a shelter for the instruments, as well as the instruments necessary for the work of the station. Provisions were stored in our cabin, where we passed the night at an altitude of about 16,000 ft. Without that the ascent would have been impossible. Several of the company suffered severely from mountain sickness, and it was only after great efforts that we could induce men and mules to continue as far as the summit. In several places it was necessary for two men to assist each of the mules that carried one of the heaviest parts of the hut. On this expedition one of the mules had a bad fall and slipped down a rocky slope, injuring himself considerably. Luckily his load consisted of rope and other articles which were not damaged by the fall.

The station consists at present of two little huts, one for the observers and the other for the instruments. They have been placed at a short distance from the iron cross which, for more than a century, has been so fitting a crown to the mountain. The station is equipped with an automatic barograph, thermograph, hygrometer, and anemometers, together with various mercurial thermometers. The first named automatic instruments run ten days, and a member of the Observatory will visit the station three times a month. The height of the station, according to measurements made in various barometric observations, is 19,200 ft. above sea level.

To the government and citizens of Peru, who have so kindly given their interest and support to this Observatory, it should be a source of pride that Peru not only possesses some of the most beautiful landscapes but that it has given to science the highest meteorological station in the world.

S. I. BAILEY.

HARVARD OBSERVATORY, AREQUIPA, Nov. 9, 1893.

Life and Work on Ben Nevis. — From the *Quarterly Journal of the Royal Meteorological Society*, Vol. XIX., No. 88, October, 1893, we take the following: "Since May, 1884, the observations on Ben Nevis have comprised a complete set of readings of all the instruments, outside as well as inside the Observatory, at every hour, by night as well as day. The day of twenty-four hours is divided into watches of eight hours at night and of four during the day. Thus there is always at least one of the observers keeping watch over the weather, and going out punctually at each hour to read the various instruments and make notes. The actual observation takes only from five to ten minutes, but during the remainder of the time there is plenty to do in reducing and filling up the daily records, checking the results, and drawing up daily and monthly averages of the readings of each instrument.

"During the months of February and March it is not uncommon to have

southeasterly gales blowing for three or four days continuously at the rate of from 80 to 100 miles an hour; but under these circumstances the hill-top is usually swept clear at once of all loose snow, and a hard surface of rough ice left, which is not touched by the wind, and on which good footing may be got. At first when the surface was icy and the wind very strong, the observers used to go out roped together, but experience has shown that even in the most violent gusts safety may be always had by lying down, and the rope is seldom used except when it is necessary to go to very exposed places. For the ordinary observations a guide-line for use at night in case of the lantern being blown out is all that is required. In steady winds the angle at which the observer leans in order to keep his footing becomes a valuable factor in estimating the wind force. The storms of early winter — November and December — usually bring a thaw, and heavy rain, which, though very disagreeable, does not interrupt the usual course of observing; the most unpleasant weather is when it rains while the temperature is still below freezing. The rain then freezes as it falls, and everything gets covered with hard ice, which may increase in thickness indefinitely, the only limit being the time that these conditions continue. On one occasion it lasted two days, and the ice was more than a foot thick both on the ground and on the windward side of all projections. This deposit of snow and ice on all exposed surfaces is one of the chief difficulties connected with the working of the instruments of the Observatory; it occurs whenever there is fog or mist on the summit.

"During summer, when the temperature is above the freezing point, the fog soaks everything exposed to it. All the instruments outside, and indeed all exposed surfaces, steam with moisture, even though there may be no rain actually falling. In winter, when the temperature is below freezing, the effect of the fog is to cover everything with long feathery masses of crystalline snow. It seems that as the fog is driven across the hill-top by the wind, and brushes against any obstruction, the moisture in it condenses in minute crystalline specks of snow or hoar frost; these accumulate until long cone-shaped crystals are formed, pointing to windward, which grow by continual accretion until they break off by their own weight. These crystals sometimes grow until they form a solid massive pillar about three feet in diameter, the nucleus of the whole being a simple wooden post some six inches by three in section. This is usually the result of several days' growth, during which time the wind shifts so as to deposit crystals from all sides on the post; but even when care is taken to keep the exposed object as clear as possible, it is impossible to wholly prevent their formation. During dense fog they will often grow at the rate of fully two feet a day. This growth rapidly chokes the louvres of the thermometer screen; if the temperature is low the crystals are loose and easily brushed off; but if near the freezing point, even without the objectionable rain mentioned above, the crystals are hard and icy and adhere firmly, needing to be chipped off. This difficulty with the thermometer screen has been overcome by using duplicate screens. When the one in use gets badly choked, no attempt is made to clear it, but it is taken in bodily and a fresh screen with other thermometers inside is

put out. The screens are placed, in winter time, on a high stand shaped like a ladder, so that the instruments can be put stage by stage higher up as the snow gets deeper, and may always be about four feet above the surface of the snow. In summer, when the top is clear of snow, an ordinary Stevenson screen is used. In these screens are four thermometers — dry bulb, wet bulb, maximum, and minimum. The dry and wet are read hourly, the maximum and minimum once a day at 9 P. M.

"Thunderstorms are rare on Ben Nevis; on the average there are only about half a dozen in the year, mostly in autumn and winter; and there have been intervals of as long as two years without either thunder or lightning being observed. Most of the ordinary summer thunderstorms are seen to pass below the hill-top, and even thunder is not heard. But when a storm does pass over the summit it is a most unpleasant experience. The cloud is seen approaching with lightning flashing from it; it then envelops the hill-top, during which time no lightning is seen, but rain or snow falls heavily, — as much as one third of an inch in ten minutes has been recorded, — and then, as the cloud moves off, a discharge takes place, not merely from the cloud but from all large metallic bodies in the Observatory; a brilliant flash springs out from the stoves, and a sharp crack like a pistol shot is heard. Some of the observers have received shocks under these circumstances, but no serious harm has been inflicted. The most severe of these storms was in January, 1890; one of the observers was almost knocked down when sitting writing, and the telegraph wire was fused, and all communication stopped for five days. This is the only occasion in eight years that the telegraph wire has failed, a very different record from that of high-level observatories situated in regions where summer thunderstorms are felt at greater heights.

"Another electrical phenomenon sometimes seen is the continuous discharge from elevated points known as St. Elmo's Fire. It usually appears like little jets of flame on the lightning-rod, anemometers, etc., but in the more brilliant displays every post and chimney is tipped with fire, and sparks glimmer on the observer's hat, pencil, or fingers. It is always accompanied by a peculiar hissing or buzzing noise, and almost invariably by a heavy fall of soft hail or conical-shaped snow. It is most frequent in winter, but it may sometimes be observed in stormy weather in summer. The optical meteorological phenomena observed on Ben Nevis are of great interest and beauty."

Thunderstorm Studies in Bavaria since 1879. — In the *Beobachtungen der meteorologischen Stationen im Koenigreich Bayern*, Vol. XIV., for 1892, there is a paper embodying the results of the thunderstorm investigation carried on in Bavaria since 1879, prepared for Section B of the Chicago Congress of Meteorology by Dr. Franz Horn. The thunderstorm work in Bavaria was begun under the direction of Dr. von Bezold, at that time the Chief of the Bavarian Weather Service, and was carried on by him until his removal to Berlin in 1885. Since then Dr. Carl Lang, whose recent death has removed one of the prominent European meteorologists, has had the

direction of the investigation. The present paper is a concise summary of the many points of interest which have been brought out from year to year, as the records have been reduced and charted. Although this JOURNAL has recently contained an account of the chief results of these thunderstorm studies (Vol. X., pp. 111–113), a short review of Dr. Horn's useful compilation may not be out of place.

One of the most noticeable facts brought out in the study of the thunderstorms of Bavaria is the difference in character of these storms from year to year. In some years they are distinguished by their extended storm-fronts, and are readily charted, while in other years the characteristics are many small storms, lasting a short time and difficult to chart. In some years, also, thunderstorms moving from the east are quite common, while usually the movement is from west to east. There appear to be two distinct types of thunderstorms: those distinguished by extended storm-fronts, and those which have been well called erratic thunderstorms. The former type prevailed at the beginning of the last decade; the latter in the last half of that decade. The years 1890–1891 show a slow return to the prevalence of the first type. From 1879 to 1884 the number of thunderstorms decreased; it increased decidedly to 1889, and since then has slowly decreased down to the present time. The rate of movement also varies, but in the contrary way. From 1879 to 1884–5 the velocity increased; from 1884–5 to 1889 there came a decrease, and from 1889 to 1891 an increase again. This change corresponds to a change in the location of some of the cyclone tracks over northern Europe, these having shifted from a more maritime to a more continental position between 1879 and 1884–5, and returned to their original position between 1885 and 1890. 1879 and 1888 were years of sunspot minima and also years of minimum velocity of thunderstorms. In 1884–5 there came a period of sunspot maxima and the velocity of thunderstorms was also at its maximum, while the period of sunspot minima in 1889 was accompanied by a minimum velocity of thunderstorms.

The velocity of thunderstorm movement is greater in winter than in summer, the winter rate of movement being 51.2 kms. an hour, and the summer rate 43.3 kms. The maximum frequency of thunderstorms is in the afternoon and early morning, the chief maximum being in the afternoon, one or two hours after the time of maximum temperature. The diurnal period of velocity shows a maximum at midnight and a minimum about noon.

One of the most interesting points brought out in this study of the records of the year 1880 was the fact that thunderstorms moving from east to west occur on the northern side of cyclonic depressions, while those moving from west to east occur on the southern side of such depressions. These secondary storms thus have the same direction of movement as that of the winds around an area of low pressure. Further investigation, especially that regarding the thunderstorms of 1889, has revealed the fact that in cases where a depression is so situated that thunderstorms can be traced on all sides of it, these storms move around it on all sides in the general left-handed spiral of the wind circulation. In other words, the thunderstorms on the southern side of the depression move from the west; those on the

northern side from the east, etc. Therefore it follows that years which are distinguished by the passage of many cyclones to the southward, are also distinguished by many thunderstorms moving from east to west, as has been seen to be the case.

A comparison of the annual temperature curve and of that of the annual frequency of thunderstorms shows a marked correspondence. Further it is found that the thunderstorm fronts show decided sudden advances when approaching a region of great relative humidity, while when a region of less relative humidity is reached the advance of the storm is checked. Neither rivers, lakes, nor forests seem to give any protection against damage by hail.

Annual Report of the Work of the Prussian Meteorological Institute.—Dr. von Bezold's annual report on the work of the Prussian Meteorological Institute, of which he is the Director, shows an encouraging condition of affairs in that service. During the year 1892 the desired number of rain-gauge stations was completed and the meteorological and magnetic observatory at Potsdam began its work. It is interesting to note the names of the men who are in charge of the service, and also the way in which the work is divided. The Director is Dr. von Bezold and Dr. Hellmann is Vice-Director; Dr. Kremser is in charge of the division of climatology, assisted by Dr. Kassner; the division of bibliography is in charge of Dr. Hellmann; that of thunderstorms and extraordinary atmospheric phenomena, as well as the instrument division, is under Dr. Assmann; Dr. Sprung has the direction of the observatory at Potsdam. The number of stations of the second, third, and fourth classes is 190, and this number is to be maintained hereafter, if possible. The number of "rain-stations" was increased during the year by the addition of 282 new ones, bringing the number up to 1,707. As the regular stations already mentioned also take observations of precipitation the whole number of stations recording precipitation is 1,897. In order to keep up the interest of the observers, 200 copies of the monthly publication, "Das Wetter," were sent out at the expense of the Institute. An effort will be made to send this magazine to all the observers hereafter. Thunderstorm reports was received from 1,419 observers, who sent in 30,978 cards.

Admirable work has been done by the Institute in the comparison of instruments and their verification, and in sending out a large number of instruments of various kinds, including 371 pairs of rain-gauges. Dr. Assmann, Dr. Hellmann, Dr. Kremser, and Dr. Sprung inspected a large number of the stations during the year. The change in the method of publication of the results has already been referred to in the November number of this JOURNAL (page 328). The usual meteorological observations have been published, together with a long list of articles written by members of the staff of the Institute. The new observatory at Potsdam is now nearly ready, and regular observations are being made there beginning with the new year. A further admirable work of the Institute has been the setting up of a number of so-called "Urania columns" in Berlin. These columns are fitted up with self-registering instruments and have excited a great deal of interest.

Meteorological Work in Southwestern Russia. — Dr. Klossovsky has recently published a short account of the development of meteorological work in southwestern Russia, under the title of *Une Page de l'Histoire du Réseau météorologique privé de la sud-ouest de la Russie.* The work was begun in 1885, through the energetic efforts of Dr. Klossovsky, and in that year the sum of 1000 roubles was voted by the government of Kherson to pay the expenses of instruments, bulletins, etc. By February, 1886, 60 rain-gauges had been distributed in the different districts, and at the end of that month the Observatory of the University of Odessa began the publication of its bulletins. Towards the end of 1886, 67 rain-gauge stations were in operation. In addition to records of precipitation, to which the observations were first limited, data were soon collected as to temperature, cloudiness, direction and force of the wind, torrential rains, lightning strokes, etc. In 1890 a special extension of the work in the interests of agriculture was made, and with the generous assistance of the press, together with the growing interest in meteorology, a rapid increase in the number of stations resulted. Dr. Klossovsky has adopted a plan in his work which might well be adopted elsewhere. All new observers are at first required to make only the simpler observations, without the aid of instruments, but as soon as they have learned to do this accurately they are given the instruments, first the rain-gauge, and then the others in a progressive gradation. The growth of the stations has been remarkable. In 1886 there were 67; in 1887, 158; in 1888, 233; in 1889, 204; in 1890, 483; in 1891, 658, and in 1892 the Odessa Observatory received observations from 1,648 stations and 1,904 observers. The amount and variety of the work being done by this meteorological service is really remarkable, and does the greatest credit to the energy and perseverence of Dr. Klossovsky and of his assistants, as well as to the interest of the volunteer observers. Among the many valuable publications already issued may be mentioned articles on the thunderstorms of Southern Russia; the temperature of the soil in southwestern Russia; the shape of hail-stones, and oscillatious of level and of temperature in the Black Sea and the Sea of Azof. A paper on the climate of Odessa is in press. A very careful study has also been made of the torrential rains of southwestern Russia, and of the distribution of precipitation in cyclonic storms.

The three most recent publications issued by the meteorological service of southwestern Russia * are *Essai de Météorologie agricole,* by Dr. Klossovsky (Vol. IV., in Russian), the volume containing the meteorological data for the year (Vol. V., *Matériaux*), in Russian, and Vol. III., entitled *Météorologie générale.* The latter contains articles on The Torrential Rains of Southwestern Russia, 1886–1892, Electrometric Observations at Odessa, The Distribution of Thunderstorms over the Earth's Surface, Magnetic Anomaly of Odessa, and on Lightning Strokes in Southwestern Russia during 1886–1892. All these papers are in Russian except the one on

* Travaux du Réseau météorologique du sud-ouest de la Russie, Vols. III., IV., V. Odessa, 1893.

thunderstorms, which is in German, but there are abstracts of all of them in French.

Dr. Klossovsky's report shows a most encouraging activity in meteorological work in southwestern Russia, and the valuable results already published give promise of much more of interest and value to follow.

Thunderstorm Movement in the Neighborhood of Rivers and Mountains. — The September number of the *Meteorologische Zeitschrift* contains a note by Dr. Schmidt of Halle, on the movement of thunderstorms in the neighborhood of rivers and mountains. The author distinguishes first between the large thunderstorms, which have storm-fronts many miles or hundreds of miles in length, and the smaller local thunderstorms. The former class, whose clouds are seldom under 1000 meters high, are but little affected by local influences. In the case of the second class, however, river valleys and mountains have a marked influence.

Dr. Boernstein has stated (this Journal, Vol. X., pp. 115-116) that rivers retard the advance of thunderstorms, while mountains accelerate their velocity as they approach and lessen their rate of movement as they depart. Dr. Schmidt believes that the effect of rivers and mountains on thunderstorm movement is produced as follows: When the thunderstorm clouds, charged with electricity, reach a river, the water of the latter, and also the ground-water in the neighborhood, act as conductors of the electricity. The electrical lines of force from the clouds concentrate themselves towards the water and produce on the surface of the water an electrical condition, opposite to that which the clouds possess. The result is that there is a strong attraction in the direction in which there is the greatest concentration of these lines. This attraction at first helps the wind in driving the clouds, but as soon as the clouds have crossed the river the attractive force checks the further movement of the storm onward, and, unless the wind is especially strong, the storm moves along the river, up or down stream, according to the wind. It is this attraction which, after a thunderstorm has moved up the valley of a stream to a mountain divide, may hold the clouds in the valley and prevent the storm from crossing the mountains.

Dr. Schmidt believes that sometimes even low hills, from 100 to 200 meters high, may operate, through this attraction, to prevent the passage of thunderstorms over them, and mentions a case which he thinks illustrates this point. A thunderstorm observed in a valley between hills between 100 and 200 meters high was very severe in the valley, and, although driven against the enclosing hills, did not psss over them. The explanation of this fact Dr. Schmidt gives as follows: The hills in this case were composed of very porous rocks and were therefore unable to retain any large amount of water on their slopes. The result was that the water collected on the more solid rock strata of the valleys below, and the attraction exerted by this water at the base was sufficient to hold the storm there and so prevent its crossing the hills. In cases where the wind is strong enough, the storm may be carried across the hills in spite of the force which holds it to the valley.

The Climate of Greenland. — In *Ciel et Terre* for August 16, 1893, M. W. Prinz has an article on the Climate of Greenland in Former Times and To-day, in which several accounts bearing on the climate of Greenland are brought together. There is a very general impression that Greenland formerly enjoyed a much less severe climate than is found there now, and that it was covered with a vegetation sufficiently abundant to make it in reality a Green Land and to support a numerous population which has now disappeared. The name, however, appears to have been given to the country by one of the early voyagers to it from Iceland, who, in order to attract settlers, gave it a name which should act as a powerful stimulus to this desired immigration. His description of the new land he had seen induced a number of persons to accompany him on his return to Greenland about the year 990.

A writer at the end of the 12th century, who was probably a Norwegian king, describes the immense fields of ice both on land and on the neighboring ocean waters. He says that the ice is so thick on the land that mountains and valleys are hidden under it, and that the only habitable places are the shores of certain fjords. The country is stated to be the coldest region in the world, and even the heat of summer is declared to be so slight that grain will not ripen, and that therefore most of the inhabitants have never seen cereals or eaten bread. At the time this account was written the colonists were in a flourishing condition. There were fourteen churches, a cathedral, and two convents. The form of government was that of a republic. In the second half of the 13th century, however, the region came under the rule of the kings of Norway, and the result was fatal to the colony. The last historic document concerning Greenland at these times is the letter of Pope Nicholas V., dated September 20, 1448, addressed to the Icelandic bishops, asking them to help the unfortunate colonists in Greenland, deserted by Norway and beset by foes. From that time the name of Greenland disappeared until the 17th century, when the English and Danes undertook expeditions to that country. A Norwegian, in 1721, first reached it again, and found only Esquimaux savages in the midst of the ruins of the old Icelandic buildings. To-day the population of Greenland numbers about 10,000. The writer believes as a result of his investigation that there has been no appreciable change in the climate of Greenland in historic times, the earliest account describing a condition of things very much as it is to-day.

Recently Dr. Nansen's expedition across Greenland and Lieut. Peary's exploration along the western coast have added much to our knowledge of the climate of Greenland. The publication of meteorological data from Greenland in the *Annales de l'Institut météorologique danois* also furnishes additional material towards a more complete study of this subject than it has until now been possible to give it.

Chart of Hail Distribution in Northern Germany from 1880 *to* 1892. — There has recently been published, by Dietrich Reimer, in Berlin, a wall chart showing the distribution of hail in the eastern part of Northern Germany, based on data collected in the years 1880 to 1892. The chart

and the accompanying text are by Ferdinand Serrazin. The following summary of the most important points contained in this publication is from a review of Mr. Serrazin's work in *Das Wetter* for August, 1893, pages 182–191.

The object of the compiler in preparing his chart was to give the farmers as full and as correct information as possible with regard to the likelihood of damage to their crops by hail. An examination of the chart shows that the hail falls along certain definite tracks or paths, running in a west to east direction, or over districts which may be described as hail-nests (*hagelnester*). The places of origin of the thunderstorms are river valleys, shallow lakes, and swampy plains, fields, and moors, all of them districts which can be well warmed by the sun's rays. High land increases the intensity of thunderstorms by favoring rainfall and the development of electricity, the windward sides of mountains being much more exposed to damage by hail than the lee sides. The province of Eastern Prussia is found to be more exposed to damage now than it was twenty-five years ago, and this change is believed by the author to be due in great measure to the decrease in forest-covered areas, partly through the destruction of trees by caterpillars and partly through the cutting down of the trees. Western Prussia, also, is more liable to damage by hail now than it was twenty years ago. The effect of forests in protecting fields to leeward of them is apparently undeniable as far as these statistics for Northern Germany go, but this protection seems to be operative only in cases of local thunderstorms, and not of the larger general storms. The results obtained from observations in Wurtemberg, as noted in the August number of this JOURNAL, page 195, go to show the contrary, viz., that forests have no influence on the formation of thunderstorms, on their movement, or on their intensity. In Bavaria, as well, there seems to be no reason for believing that forests have any influence on thunderstorms.

Temperature and Precipitation in Iowa during the Year 1892. — The Annual Report of the Iowa Weather and Crop Service for the year 1892 has recently been issued, under the direction of J. R. Sage, the Director, and Geo. M. Chappel, M. D., Local Forecast Official, assistant director. It is a neat octavo volume, of 89 pages, with many tables, and charts of the mean temperature and mean precipitation for the year. Twenty-five weekly weather-crop bulletins were issued during the crop season, the total number of copies distributed being about 35,000. About 22,000 copies of the Monthly Review were sent out in addition. Forty-six stations equipped with meteorological instruments reported every month, and thirty-eight additional observers sent weekly crop reports from April 1 to October I.

From the Annual Summary the following data are taken: The mean pressure for the year was 30.060 inches; the mean temperature was 47.1°; the highest reported was 104° on July 11, at Glenwood, and the lowest —38° on January 19, at Atlantic; the range for the State being 142°, and the average monthly range, 54.5°. The average precipitation was 37.12 inches; the greatest monthly rainfall, 14.16 inches; the least, .00 inch; the greatest amount in twenty-four consecutive hours, 6.19 inches. The prevailing wind direction was northwest; the maximum velocity, 64 miles an hour.

Seven-Day Thunderstorm Periods. — In the October number of *Das Wetter*, Dr. Polis has an article on the thunderstorms of Aix-la-Chappelle, in which some interesting facts as to the occurrence of thunderstorms with greater frequency on certain days of the week are brought out. The number of thunderstorms on the different days, based on five-year averages, is given in the following table: —

Years.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
1836–40	8	10	**14**	10	12	9	10
1841–45	7	3	2	**10**	6	4	6
1846–50	**9**	5	8	8	**9**	8	5
1861–65	5	8	3	10	**12**	6	6
1866–70	10	**17**	11	7	9	6	13
1871–75	13	14	9	15	9	**16**	15
1876–80	11	14	16	15	13	14	**18**
1881–85	**20**	15	12	9	10	8	16
1886–90	9	**17**	12	12	11	15	14

A similar table, based on ten year averages, gives similar results. It will be seen at once that in the years 1836–65 the maximum comes in the middle of the week, but is gradually displaced, in later years, towards the end and then to the beginning of the week. The years 1853–60 give a maximum on Thursday, with a primary minimum on Friday and a secondary minimum on Monday. The years 1861–92 give a maximum on Monday, and a minimum on Thursday. Taking the years 1833–92 the maximum falls on Monday and the minimum on Friday. During the last thirty years there has been a marked decrease in the number of thunderstorms on Sunday and the appearance of a secondary maximum on Saturday. The author believes that this peculiarity is undoubtedly connected with the increase in the number of factories and to the decrease of smoke from the furnaces on Sunday. In this JOURNAL for July, 1893, p. 145-6, there was a note on some results of a similar kind, recently published by Dr. Kassner, of Berlin, on the weekly periods of the thunderstorms of Berlin.

Comparison of Sunshine Values on Ben Nevis, the Obir and the Sonnblick. — Dr. Hann, in the September number of the *Meteorologische Zeitschrift*, has a review of Mr. R. C. Mossman's recent paper on the "*Sunshine Values at Ben Nevis Observatory*" (see this JOURNAL for August, 1893, pp. 191, 192), in which he gives a comparison of the Ben Nevis results with those obtained on the Obir (6,716 feet) and the Sonnblick (10,154 feet). It appears from the tables given by Dr. Hann that while Ben Nevis has its maximum sunshine in June, the Obir and the Sonnblick have their maximum in February and December, respectively. Ben Nevis has only 16% of the possible sunshine during the year, while the Sonnblick has 34 % and the Obir 37%. The diurnal maximum comes between 10 and 11 A. M. at the two Alpine stations, and between 11 A. M. and noon on Ben Nevis.

CORRESPONDENCE.

THE CAUSES OF RAINFALL AND SURFACE CONDITIONS.

Editor of the American Meteorological Journal:

In regard to the comments made by Dr. Woeikof in his valued criticism of my recent article entitled "Analysis of the Causes of Rainfall with Special Relation to Surface Conditions," I should like to make the following statements: In citing the quotation from Blanford I had no intention of ascribing to him the credit of first calling attention to the importance of dynamic cooling as a cause of rain. My special object was to emphasize the fact, that has recently gained additional confirmation, namely, that *other causes are relatively unimportant*, and this quotation very concisely expresses the idea.

With reference to my description of the equatorial belt as one of calms and heavy rains, Dr. Woeikof mentions districts that have high winds and other districts that have scanty rainfall. These are important exceptions to the general statement, and should be considered by every student of climatology, but as the detailed examination of these exceptions lay outside the scope and purpose of my paper, I simply presented the general features which broadly characterize the equatorial belt as a whole.

G. E. CURTIS.

CLAPHAM, NEW MEXICO, Nov. 8, 1893.

BIBLIOGRAPHICAL NOTES.

BLUE HILL METEOROLOGICAL OBSERVATIONS FOR 1892.

Observations made at the Blue Hill Meteorological Observatory, Massachusetts, U. S. A., in the Year 1892, *under the Direction of A. Lawrence Rotch, A. M.* With Appendices containing *Investigations on Atmospheric Electricity* and *Sudden Temperature Changes.* Annals of the Astronomical Observatory of Harvard College, Edward C. Pickering, Director. Vol. XL., Part II. 4to. Cambridge, Mass., Pp. 67–138. Pl. 1.

The annual volume of Blue Hill observations is at hand. During the year 1892, Mr. H. H. Clayton has finished a discussion of the diurnal and annual periods in the cloud movements in the upper air, and has continued his researches on the motions of the upper air around cyclones and anticyclones, as shown by the cloud observations at the Observatory. The results will be published in the Annals of the Harvard College Observatory. Mr. Clayton gave some account of this work in a paper entitled *The Movements of the Air at all Heights in Cyclones and Anticyclones as shown by the Cloud and Wind Records at Blue Hill*, which was published in the August number of this JOURNAL, and the publication of his results in full will be awaited with interest. Mr. Clayton has had exceptional advantages for such researches as he has undertaken, and he has applied himself to his work with an untiring zeal. His admirable report on cloud heights and velocities, published about a year ago, has given him a high position as an authority on clouds, and there can be no doubt that his forthcoming report on the motions of the upper air around cyclones and anticyclones will be equally valuable to all meteorologists.

In addition to the varied activities of Mr. Clayton, the Blue Hill Observatory has, through Mr. S. P. Fergusson, who is now an authority on anemometers, begun a comparison of different types of anemometers in the free air, and Mr. Alexander McAdie, of the Weather Bureau at Washington, continued his researches on atmospheric electricity at the Observatory during the summer of 1892. Mr. Fergusson contributed a paper on some of the results of his comparisons to this JOURNAL for January, 1893. The experiments are to be continued at higher velocities, and other instruments of which few tests have hitherto been made, are to be included in the comparisons.

The present volume contains tables of the eye observations made twice a day, — at 8 A. M. and 8 P. M. — arranged in the international form; a summary for the year; a table of duration of sunshine and of mean and maximum

velocity of the wind; a summary of the valley station observations for the year; a table of hourly precipitation for each month and the year, and of the number of times precipitation occurred during each hour of the day for each month and the year. Other tables are a summary of the visibility of the peaks of Nobscot, Wachusett, and Monadnock Mountains, the cloud observations made thrice daily, and the hourly amount of cloud for each day, month, and the year.

Appendix C of this Report contains an account of the experiments on atmospheric electricity made by Mr. McAdie at Blue Hill from July 12 to August 12, 1892. Appendix D is a paper on Sudden Temperature Changes, by H. H. Clayton and W. H. Fergusson. In this study all the cases in which the temperature rose or fell as much as 5° in an hour were counted up from the thermographic charts for the six years 1887 to 1892 inclusive. The number of cases found was 698, and of these 373 were falls and 325 were rises. In order to eliminate the cases of diurnal change the cases were classified as follows: —

1. Sudden falls of 5° or more, preceded and followed by a slow change of nearly stationary temperature. 2. Sudden rises of 5° or more, preceded and followed by a slow change or nearly stationary temperature. 3. Sudden falls of 5° or more, followed within an hour or two by a rise of nearly equal amount. 4. Sudden rises of 5° or more, followed within an hour or two by a fall of nearly equal amount.

It is found on examination of types 1 and 2 that sudden abnormal falls are more than twice as frequent as similar rises. Cases of falls of 20° or more at the rate of a degree a minute sometimes occur, while the most rapid rise of 10° or more was at the rate of 1° in five minutes. The most frequent sudden falls are in June and July, the fall being coincident with the setting in sea breezes. As regards the causes of these sudden changes, it appears that 96 per cent of the changes of type, occurred with sudden shifts of wind; in winter the shifts were to some point between west and north; in summer, to some point between north and east. In several cases of falls with a sea-breeze, the fall occurred about 60 minutes after the wind became east, showing that it takes about an hour for the coldest air to reach Blue Hill from the sea.

The sudden rises of type 2 are mostly coincident with sudden breaking of clouds and the appearance of sunshine, or with sudden shifts of wind to the south, the latter cases occurring in the winter months only. The temporary depressions of temperature of type 3 are apparently due to two causes; a temporary shift of wind to a cold quarter, and a cutting off of the sunlight by the passage of a dense cloud. The falls of the latter case are increased by a fall of rain, and are greatest with heavy thundershowers. The elevations of temperature of type 4 appear to result from several causes: 1, a temporary shift of wind to a warmer quarter; 2, a brief appearance of sunshine caused by a temporary break in a veil of cloud; 3, a temporary clouding up on a clear night, when the temperature is decidedly lower near the ground than several hundred feet above it; 4, a descent of air on nights like the preceding probably caused by a sudden increase of wind velocity; 5, the passage through the central area of a deep cyclone.

The latter part of Mr. Clayton's paper is taken up with an account of cyclonic and anticyclonic temperature changes. Mr. Clayton's chief results in this work have already been given by him in a paper entitled "Six and Seven Day Weather Periodicities" in the May number of this JOURNAL, pp. 35-44, so that a review of this investigation is here unnecessary.

The value of the work that Blue Hill Observatory has done for meteorology is very great, and Mr. Clayton's present researches on the motion of the upper air and on the question of periodicities in temperature and weather changes will doubtless lead to many further noteworthy results. The present volume is illustrated by two views showing the base and valley stations of Blue Hill Observatory.

INFLUENCE OF FORESTS ON CLIMATE AND AGRICULTURE.

C. P. CRONK. *Influence of Forests on Climate and Agriculture.* In: Monthly Report of the Maryland State Weather Service for October, 1893. Pp. 57, 58.

The question as to how far forests have an influence on climate, and especially on precipitation, is one on which much has been written and about which there have been many widely different opinions. Until within the last few years, however, the conclusions have been based upon very inaccurate data, so that in most cases the results are very untrustworthy. Lately, through the valuable observations made at the forest meteorological stations in Germany, France, and other European countries, we are beginning to have some satisfactory basis on which to work in this investigation, and the next few years will undoubtedly bring out many new and interesting facts in this connection. In view of the fact that most of the conclusions as to the effect of forests on climate have been, as just stated, based on insufficient or inaccurate data, and in many cases on insufficient as well as inaccurate data, it is not possible, as yet, to make any very definite statements on this subject.

In the Monthly Report of the Maryland State Weather Service for October, Dr. C. P. Cronk, of the Weather Bureau in Baltimore, has a short article on the "Influence of Forests on Climate and Agriculture," which contains several broad generalizations that seem to need some qualification. Certain influences of forests are well established, such as the wind-break effect, which is a very important agent in protecting crops to leeward of the trees, especially in cold or dry weather. The velocity of the wind is also checked by the rough surface of the forest. The influence of forests on the temperature of neighboring fields is brought about by means of air currents passing through and above the forests, being modified in temperature and moisture conditions, but, of course the effect is slight. Forests in general have a less range of temperature than open country, that is, their temperature is somewhat higher in winter and somewhat lower in summer than that of the open country. To say, however, as Dr. Cronk does, that trees

"warm the winters and cool the summers," is giving an importance to this effect far beyond that to which it is entitled, and such a statement is decidedly misleading to anyone who is unacquainted with the facts.

The author's remarks regarding the connection between rainfall and forests are also likely to be misleading. The question is one which has been much discussed, but which has not been satisfactorily answered as yet. There are a few cases, such as that mentioned by Blanford in India and by Müttrich at Lintzel, in which reforestation has been accompanied by an increase in rainfall, apparently in the relation of cause and effect, but, as Prof. Harrington has recently said, "the facts at hand do not prove, with entire conviction, that forests increase the rainfall." An increase in rainfall will, other things being favorable, probably be accompanied by an increased growth of trees, and in the same way a decrease in rainfall by a less growth of trees. The question, Which is the cause and which the effect? is not easy to determine. It has often been stated that the advance of civilization in our West has brought an increased rainfall along the railroads and over the plains generally, as the ground has been more extensively cultivated and more trees have been planted. In this connection Prof. Harrington some years ago endeavored to show that along the parallels of latitude 40° and 42° in the Mississippi Valley the lines of higher rainfall were moving slowly westward with the advance of settlements. He found, however, that the scattered early observations were untrustworthy, and that therefore no conclusions could be reached.

While it is discouraging to be told continually that there are insufficient data at hand to settle this or that disputed point in meteorology, or in any other science, still we must be content to wait, in this matter as in others, and must be careful not to form conclusions on untrustworthy and inaccurate statements or observations.

INVESTIGATIONS OF THE NEW ENGLAND METEOROLOGICAL SOCIETY.

Investigations of the New England Meteorological Society for the Year 1891. Annals of the Astronomical Observatory of Harvard College, Edward C. Pickering, Director. Vol. xxxi., Part II. 4to, Cambridge, 1893. Pp. 161–343; pl. VI.–X.

The annual volume of observations of the New England Meteorological Society for the year 1891 is prefaced, as usual, by an introduction by Prof. W. M. Davis, the Director of the Society. As is doubtless known to the readers of this JOURNAL, the society transferred all its routine work of observation to the National Weather Bureau in March, 1892, thus forming the New England Weather Service, which was put under the directorship of Mr. J. Warren Smith, the former assistant to the Director of the Society. The present volume of observations is therefore the last one which will be issued under the auspices of the Society, although it is hoped that further investigations may be carried on and published in the Annals of the Harvard

College Observatory, as heretofore. The Society is now relieved of the large amount of routine work connected with the work of the observations, and is left free to hold its meetings for general discussion or to undertake the special investigations which from its first organization have been one of the prime objects of its existence.

The present volume contains the usual meteorological summary for the year, by Mr. J. Warren Smith, and the usual tables giving the meteorological data. It also contains the report on the Thunderstorms in New England during the years 1886 and 1887 by Mr. Robert De C. Ward, Assistant in Meteorology in Harvard College, which was reviewed in the December number of this JOURNAL.

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